

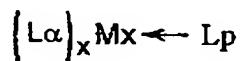
## Claims

1. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of a first electroluminescent metal complex or organo metallic complex, (iii) a layer of a second metal complex or organo metallic complex and (iv) a second electrode and in which the band gap of the second electroluminescent metal complex or organo metallic complex is larger than the band gap of the first electroluminescent metal complex or organo metallic complex.
- 5 2. An electroluminescent device as claimed in claim 1 in which the metal in the first and second electroluminescent metal complex or organo metallic complex is selected from Sm(III), Eu(II), Eu(III), Tb(III), Dy(III), Yb(III), Lu(III), Gd (III), U(III), U(VI)<sub>2</sub>O<sub>7</sub>, Tm(III), Th(IV), Ce (III), Ce(IV), Pr(III), Nd(III), Pm(III), Dy(III), Ho(III), Er(III).
- 10 3. An electroluminescent device as claimed in claim 1 in which the metal in the first electroluminescent metal complex or organo metallic complex is europium or terbium and the metal in the second electroluminescent metal complex or organo metallic complex is gadolinium or cerium.
- 15 4. An electroluminescent device as claimed in claim 1 or 2 in which the metal in the first electroluminescent metal complex or organo metallic complex and the metal in the second electroluminescent metal complex or organo metallic complex are the same.
- 20 5. An electroluminescent device as claimed in any one of claims 1 to 4 in which there are more than one layer of each of the first and second electroluminescent metal complex or organo metallic complexes arranged alternatively.
- 25 6. An electroluminescent device as claimed in any one of claims 1 to 5 in which the first electroluminescent metal complex or organo metallic complex has the formula (La)<sub>n</sub>M1 where La is an organic complex M1 is the metal and n is the valence state of M1 and the second electroluminescent metal complex or organo metallic complex has

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the formula  $(La)_nM_2$  where  $La$  is an organic complex,  $M_2$  is the metal and  $n$  is the valence state of  $M_2$ .

7. An electroluminescent device as claimed in any one of claims 1 to 5 in which the  
5 metal complex or organo metallic complexes have the formula



(A)

where  $M_x$ ,  $x$ ,  $La$  and  $L_p$  are as defined herein and the ligands  $La$  can be the same or different and there can be a plurality of ligands  $L_p$  which can be the same or different.

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8. An electroluminescent device as claimed in any one of claims 1 to 4 in which at least one of the metal complex or organo metallic complexes have the formula  $(La)_nM_xM_3$  where  $M_3$  is a non rare earth metal,  $La$  is as defined herein and  $n$  is the combined valence state of  $M_x$  and  $M_3$ .

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9. An electroluminescent device as claimed in any one of claims 1 to 4 in which at least one of the metal complex or organo metallic complexes have the formula  $(La)_nM_xM_3(L_p)$ .

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10. An electroluminescent device as claimed in claim 9 in which the metal  $M_3$  is any metal which is not a rare earth, transition metal, lanthanide or an actinide.

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11. An electroluminescent device as claimed in claim 9 in which the metal  $M_3$  is selected from lithium, sodium, potassium, rubidium, caesium, beryllium, magnesium, calcium, strontium, barium, copper (I), copper (II), silver, gold, zinc, cadmium, boron, aluminium, gallium, indium, germanium, tin (II), tin (IV), antimony (II), antimony (IV), lead (II), lead (IV) and metals of the first, second and third groups of transition metals in different valence states, e.g. manganese, iron, ruthenium, osmium, cobalt, nickel, palladium(II), palladium(IV), platinum(II), platinum(IV),

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cadmium, chromium, titanium, vanadium, zirconium, tantalum, molybdenum, rhodium, iridium, titanium, niobium, scandium, yttrium.

12. An electroluminescent device as claimed in any one of claims 1 to 11 in which  $L\alpha$  is of formula (I) to (XVII) herein.
13. An electroluminescent device as claimed in any one of claims 1 to 11 in which  $Lp$  is of formula (XVIII) to (XXV) herein or figs. 1 to 9 of the drawings
14. An electroluminescent device as claimed in any one of claims 1 to 13 in which  $L\alpha$  is selected from tripyridyl and TMHD, and TMHD complexes,  $\alpha$ ,  $\alpha'$ ,  $\alpha''$  tripyridyl and  $Lp$  is selected from crown ethers, cyclans, cryptans phthalocyanans, porphoryins ethylene diamine tetramine (EDTA), DCTA, DTPA and TTHA.
15. An electroluminescent device as claimed in any one of claims 1 to 14 in which the europium complex is  $Eu(DBM)_3OPNP$ .
16. An electroluminescent device as claimed in any one of claims 1 to 15 in which the gadolinium complex is  $Gd(DBM)_3Phen$ .
17. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of an electroluminescent europium metal complex or organo metallic complex mixed with an iridium metal complex or organo metallic complex and (iii) a second electrode.
18. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of an electroluminescent europium metal complex or organo metallic complex, (iii) a layer of an electroluminescent europium metal complex or organo metallic complex mixed with an iridium metal complex or organo metallic complex and (iv) a second electrode.

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19. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of an electroluminescent europium metal complex or organo metallic complex mixed with an iridium metal complex or organo metallic complex, (iii) a layer of an electroluminescent europium metal complex or organo metallic complex and (iv) a second electrode.
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20. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of an electroluminescent europium metal complex or organo metallic complex, (iii) a layer of an electroluminescent europium metal complex or organo metallic complex mixed with an iridium metal complex or organo metallic complex, (iv) a layer of an electroluminescent europium metal complex or organo metallic complex and (v) a second electrode.
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21. An electroluminescent device as claimed in any one of claims 17 to 20 in which the europium metal complex or organo metallic complex has the formula  $(La)_3Eu$  where La is an organic complex.
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22. An electroluminescent device as claimed in any one of claims 17 to 19 in which the europium metal complex or organo metallic complex has the formula
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- $$\left( La \right)_3 Eu \leftarrow\!\!\!-\! Lp$$
- (AI)
- where La and Lp are organic ligands and Lp is a neutral ligand, the ligands La can be the same or different and there can be a plurality of ligands Lp which can be the same or different.
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23. An electroluminescent device as claimed in any one of claims 17 to 19 in which the europium metal complex or organo metallic complex has the formula  $(La)_nEuM_2$  where M<sub>2</sub> is a non rare earth metal, La is as herein and n is the combined valence state of Eu and M<sub>2</sub>.
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24. An electroluminescent device as claimed in any one of claims 17 to 19 in which the europium metal complex or organo metallic complex has the formula  $(L\alpha)_n Eu M_2 (Lp)$ , where Lp is as herein.
- 5    25. An electroluminescent device as claimed in claim 24 in which the metal  $M_2$  is any metal which is not a rare earth, transition metal, lanthanide or an actinide.
26. An electroluminescent device as claimed in claim 24 in which the metal  $M_2$  is selected from lithium, sodium, potassium, rubidium, caesium, beryllium, magnesium, calcium, strontium, barium, boron, copper (I), copper (II), silver, gold, zinc, cadmium, boron, aluminium, gallium, indium, germanium, tin (II), tin (IV), antimony (II), antimony (IV), lead (II), lead (IV) and metals of the first, second and third groups of transition metals in different valence states, e.g. manganese, iron, ruthenium, osmium, cobalt, nickel, palladium(II), palladium(IV), platinum(II), platinum(IV), cadmium, chromium, titanium, vanadium, zirconium, hafnium, tantalum, molybdenum, rhodium, iridium, titanium, niobium, scandium, yttrium.
- 10    15    27. An electroluminescent device as claimed in any one of claims 17 to 26 in which  $L\alpha$  is of formula (I) to (XVII) herein.
- 20    28. An electroluminescent device as claimed in any one of claims 17 to 26 in which Lp is of formula (XVIII) to (XXV) herein or figs. 1 to 9 of the drawings.
- 25    29. An electroluminescent device as claimed in any one of claims 17 to 28 in which  $L\alpha$  is selected from tripyridyl and TMHD, and TMHD complexes,  $\alpha$ ,  $\alpha'$ ,  $\alpha''$  tripyridyl and Lp is selected from crown ethers, cyclans, cryptans phthalocyanans, porphoryins ethylene diamine tetramine (EDTA), DCTA, DTPA and TTHA.
- 30    30. An electroluminescent device as claimed in any one of claims 17 to 29 in which the europium complex is  $Eu(DBM)_3OPNP$ .

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31. An electroluminescent device as claimed any one of claims 1 to 30 in which there is a layer of a hole transmitting material between the first electrode and the electroluminescent layer.

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32. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is an aromatic amine complex.

10 33. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is a polyaromatic amine complex.

15 34. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is a film of a polymer selected from poly(vinylcarbazole), polyaniline, substituted polyanilines, polythiophenes, substituted polythiophenes, polysilanes and substituted polysilanes.

20 35. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is a film of a compound of formula (XXVI) or (XXVII) herein or as in figures 4 to 8 of the drawings.

25 36. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is a copolymer of aniline, a copolymer of aniline with o-anisidine, m-sulphanilic acid or o-aminophenol, or o-toluidine with o-aminophenol, o-ethylaniline, o-phenylene diamine or with an amino anthracene.

37. An electroluminescent device as claimed in any one of claims 1 to 30 in which the hole transmitting material is a conjugated polymer.

38. An electroluminescent device as claimed in claim 37 in which the conjugated polymer is selected from poly (p-phenylenevinylene)-PPV and copolymers including PPV, poly(2,5 dialkoxyphenylene vinylene), poly (2-methoxy-5-(2-methoxypentyloxy-1,4-phenylene vinylene), poly(2-methoxypentyloxy)-1,4-phenylenevinylene), poly(2-methoxy-5-(2-dodecyloxy-1,4-phenylenevinylene) and other poly(2,5 dialkoxyphenylenevinylenes) with at least one of the alkoxy groups being a long chain solubilising alkoxy group, poly fluorenes and oligofluorenes, polyphenylenes and oligophenylenes, polyanthracenes and oligo anthracenes, 10 ploythiophenes and oligothiophenes.
39. An electroluminescent device as claimed in any one of claims 31 to 38 in which the electroluminescent compound is mixed with the hole transmitting material.
- 15 40. An electroluminescent device as claimed in any one of claims 1 to 39 in which there is a layer of an electron transmitting material between the cathode and the electroluminescent compound layer.
- 20 41. An electroluminescent device as claimed in claim 40 in which the electron transmitting material is a metal quinolate.
42. An electroluminescent device as claimed in claim 41 in which the metal quinolate is an aluminium quinolate or lithium quinolate.
- 25 43. An electroluminescent device as claimed in claim 39 in which the electron transmitting material is of formula  $M_x(DBM)_n$  where  $M_x$  is a metal and DBM is dibenzoyl methane and  $n$  is the valency of  $M_x$ .
44. An electroluminescent device as claimed in claim 40 in which the electron transmitting material is a cyano anthracene such as 9,10 dicyano anthracene, a

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polystyrene sulphonate or a compound of formulae shown in figure 2 or 3 of the drawings.

45. An electroluminescent device as claimed in any one of claims 40 to 44 in which  
5 the electron transmitting material is mixed with the electroluminescent compound.
46. An electroluminescent device as claimed in any one of the claims 1 to 45 in which  
the first electrode is a transparent electricity conducting glass electrode.
- 10 47. An electroluminescent device as claimed in any one of the claims 1 to 46 in  
which the second electrode is selected from aluminium, calcium, lithium, magnesium  
and alloys thereof and silver/magnesium alloys.